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DESIGN PARTICULARS OF PRODUCTION LINES TRANSPORTING GLASS BATCH

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The design particulars of production lines transporting glass batch from compound shops to glassmaking furnaces. Variants of schemes using above- and below-ground galleries are presented. The advantages and disadvantages of different transport-process equipment, affecting the quality of the glass batch, are determined.

Key words: glass batch, production-flow line, batch separation, gallery, container transport.

The final stage of the technological process preparing glass batch is unloading a multicomponent mixture of raw materials from a mixer, after which either the batch is transported into a machine-tank shop and distributed among the loading hoppers of the glassmaking furnace or unloaded into buckets or storage bins, which provide definite process storage (usually for one shift) of the batch. The diversity of equipment used for transporting the batch is determined by the methods used for preparing and measured loading of the batch and cullet into the glass-making furnace, the number of loaders, the construction of the furnace well, the length of the process-flow lines, the relative arrangement of the compound and machine-tank shops, and other factors,

The most common elements found in process-flow lines for transporting glass batch in modern compound and machine-tank shops are belt conveyors, elevators, and various mechanisms for changing the flow.

Elevator-based flow schemes are most often used in the production of glass containers and make it possible to raise batch rapidly from the level of the unloading hopper of a mixer to the upper level of the hoppers of the furnace loaders, decrease the length of the gallery transport process lines, and decrease the batch transport time, which affects the batch separation and compaction processes.

When elevators lift batch directly into the compound shop (Fig. 1) the batch is transported along above-ground (from 8 to 20 m high) heated and unheated galleries and structures, and when the batch is lifted into the machine-tank shop it is transported along below-ground channels and tunnels (Fig. 2).

There are a number of advantages to transporting batch below ground as opposed to above ground: the batch is not subjected to daily and seasonal fluctuations of the environmental temperature; additional heating is not required in a below-ground gallery; less equipment is required in the line feeding measured amounts of the plant's own (returned) cullet; the planning of the grounds surrounding the production shops is optimized. The drawbacks are: the cost of wa-

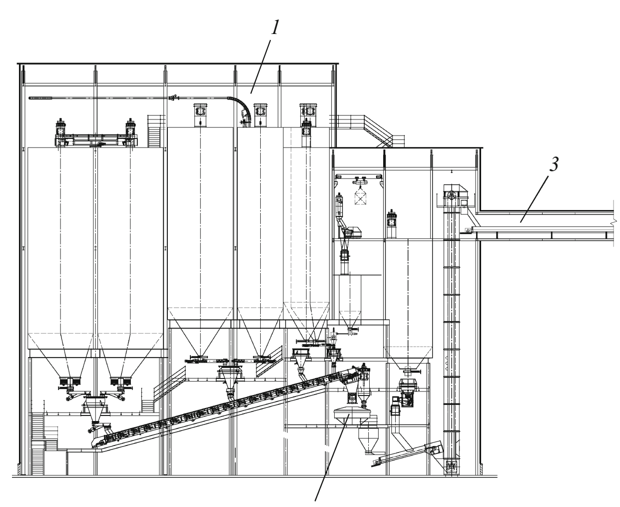

Fig. 1. Process line for transporting glass batch from an above-ground galley (the mixers are at the bottom): *1*) compound shop; *2*) batch mixers; *3*) batch transport gallery.

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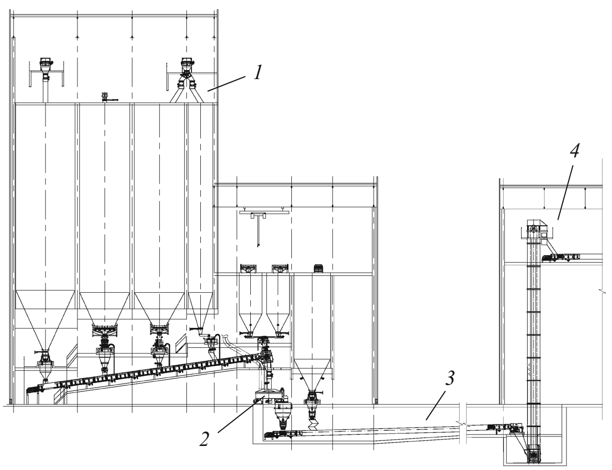

Fig. 2. Process line for transporting glass batch from a below-ground gallery: *1*) compound shop; *2*) batch mixers; *3*) batch transport gallery; *4*) machine-tank shop.

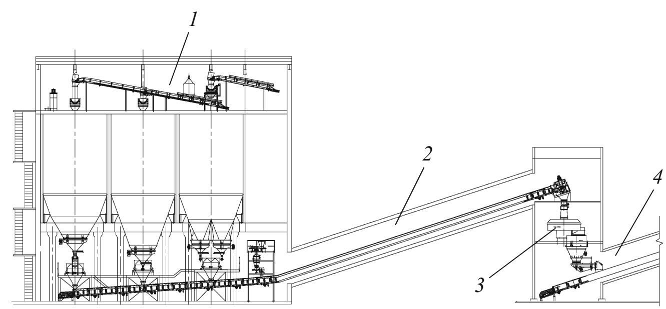

Fig. 4. Transport process line of glass batch with an inclined gallery (the mixers are removed from the compound shop): *1*) compound shop; *2*) transport gallery of the batch components; *3*) batch mixers; *4*) transport gallery of the batch.

ter-proofing below-ground structure is high; there are definite difficulties and limitations in the designing and building an in-ground water grid, sewage system, and heating grid; assembly, repair, and operation of conveyer equipment must be done under cramped conditions; the requirements for lighting, ventilation, and fire safety are more stringent.

In the production of sheet glass, conventionally, preference is given to schemes without elevators. In these schemes the batch is transported along inclined galleries (Fig. 3) with minimal repeated pouring from a container onto the conveyer. This eliminates any possible separation of a multicomponent mixture, partially arising when some batch spills during lifting in the elevator shafts and during centrifugal unloading from the elevator buckets.

However, when designing and building inclined galleries the fact that for a rise of the gallery conveyer by an angle 10 – 15° the inclined section of the gallery is at least 40 – 50 m long must be taken into account. For this reason, it is of interest to decrease this length, especially if the area of the production grounds is limited and the distance between the composite and machine-tank shops is small (20 – 30 m).

A variant of the reduction in the length of the inclined gallery is increasing the assembly conveyer of the batch components and raising the mixers to a higher building marker by transferring the mixing section to a separate room far from the compound shop by 15 – 20 m (Fig. 4). Even though it lengthens the batch preparation cycle by 10 – 15 sec such a transport scheme decreases the transport time of the ready batch and eliminates the need for building deep basements under the mixers, which is especially important when the ground water level is high at the construction location of the compound shop.

The transfer of mixers to a higher construction marker directly inside a compound shop is possible in schemes using elevators to lift measured components of a batch (Fig. 5), which also makes it possible to feed the next batch of ready mix from the mixers to the loading hoppers of the glassmaking furnace along the above-ground galleries.

Since the optimal loading time for high-productivity mixers with capacity 2250 – 4500 liters is 1 – 1.5 min, the capacity of the bucket elevators for lifting 3.5 – 5 tons of batch components over this time should be 130 – 200 m^3/h. This limits the use of such a scheme to batching-mixing lines equipped with mixers with capacity greater than 3000 liters.

When elevator-conveyer lines are used the batch is divided over the loading hoppers of the glassmaking furnaces by means of two- and three-position sleeve flow changers, left- and right-hand plow ejectors, reversing stationary conveyers, and reversing mobile conveyers-boats manufactured by “Stromizmeritel’,” JSC.

As a result of their high dust production during ejection of material and the rapid wear of the cut-off element of the

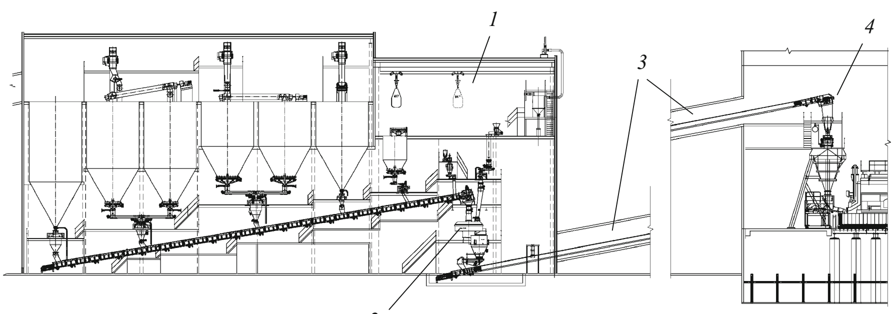

Fig. 3. Glass-batch transport process line with an inclined gallery (the mixer is at the bottom): *1*) compound shop; *2*) batch mixers; *3*) batch transport gallery; *4*) machine-tank shop.

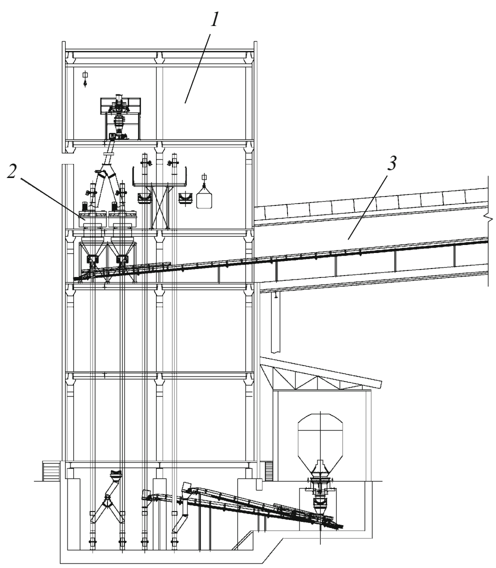

Fig. 5. Process line for transporting glass batch with an above-ground gallery (mixers located above): *1*) compound shop; *2*) batch mixers; *3*) batch transport gallery.

plow (especially when transporting cullet) plow ejectors are best used only with limited heights of the sections that change the flows of batch and cullet (for example, in below-ground galleries or in spaces between girders) as well as in facilities used for emergency removal of rejected batch and schemes that set, using metal detectors, the inadmissible concentrations of metal in the batch. Different modifications of plow ejectors placed on belt conveyers have either stationary or turning ejecting elements, controlled by electric or pneumatic drives. In structures with stationary plows the required ejection of the transported material is done by means of a small rising-lowering platform located under the belt and pressing the belt to the plow ejector from below during the rising period.

A definite advantage of plow ejectors is the possibility of installing several ejecting elements on the short section of the conveyer, for example, above the hoppers of the loaders loading batch into a transverse-flame glassmaking furnace. However, if the transported material must be distributed along two directions (loading batch into a hopper of the glassmaking furnace with a horseshoe flame) and there are no limitations on the equipment setting height, it is best to use sleeve flow changers, which eliminate losses and dust production from the material.

For more uniform loading of the mixture of the batch and cullet into the hoppers of the glassmaking furnace with a wide loading pocket (the number of the batch loaders in a large furnace producing float-glass can reach 8 – 11), it is best to use reversing mobile conveyer-boat, moving smoothly on the rails along the entire loading zone of the hoppers.

Augur conveyers with different screw direction of the augurs with respect to the loading point of the batch, turning carousel mechanisms which pull the batch apart from the center of a hopper to its periphery, and other nonstandard facilities and mechanisms are sometimes used to distribute the batch along the entire width of the loading hoppers.

It is obvious that the processes of transporting and distributing the batch over the hoppers are different in different glass plants [1]. In modern plants the length of the transport flows of the batch are negligible and constitute several tens of meters while in other plants, especially old ones producing glass containers and sheet glass these lines are longer than 100 m and reaches 300 – 400 m in individual plants. Batch transport over such distances, using conveyer lines with a substantial number of pourings materials results in separation and compaction of the batch, a decrease of its temperature and moisture content, as well as the formation of crystal hydrates in the batch under certain conditions [2].

Various measures are being developed to decrease the negative effect of these factors on the quality of the batch: the number of pourings of the batch is being decreased; the belt conveyers are being hermetically sealed; the required temperature regime is being provided in the transport galleries; the initial moisture content in the batch is being increased. Increasing the moisture content from 3 – 4.5 to 6 – 7% makes it possible to compensate for the evaporation of water from the batch during transport, but it results partially in undesirable compaction of the batch. In addition, batch with higher moisture content cannot be removed from the receiving hopper as well and is prone to stick constantly to the inner surfaces of the elevator shafts and conveyer belts, which has an especially negative effect on the batch transport process in the unheated above-ground galleries during the winter. It is important to heat and thermally insulate a transport gallery which is several hundreds of meters long, but this requires substantial capital expenditures.

The separation and quality reduction of glass batch transported over large distances are smallest when the batch is transported in buckets, electric cars, or containers.

Batch transport in buckets within a shop is accomplished using electric telphers or single-rail overhead traveling cranes, controlled manually by an operator, and is ordinarily used in the production of high-end dishware, glass containers of certain sizes, electro-vacuum apparatus, glass insulators, and other products. The lines feeding batch from the mixing to the batch loading hoppers (such a line is in operation at the L'vov electric-lamp plant) can be controlled automatically, but the productivity of these lines is limited by the fact that only one self-unloading bucket with a small volume and transported by an electric telpher is used in each transport cycle.

Manual and electrically driven telphers are used to transport batch-loaded buckets between shops, if the shops are adjacent to one another or by motor vehicle if the distance between the composite and machine-tank shops is several hundred meters. Batch can be transported in buckets even over several tens of kilometers with from one glass plant to another. In this case, with partial separation of the batch and a decrease of its moisture content during transport and inter-

mediate storage the batch is additionally mixed and additional moisture is added to the batch in a mixer installed at the user's location. The installation of such a mixer makes it possible, together with adding water, to introduce into batch containing the basic components agents that colorize or decolorize the molten glass.

Electric telphers have been used in the production of sheet glass to transport batch over large distances, but at present such transport means are used less and less and in the course of reconstruction they are replaced with conveyer lines or container systems for feeding the batch.

Replacing cars which are controlled by a machinist (pouring batch) by belt conveyers makes it possible to automate the process of transporting batch, prevents possible emergency situations, and decreases injuries to maintenance workers. But this technical solution does not always preserve the quality of the initial batch, since for a 300 – 400 m path and 1 m/sec velocity of the conveyer belt the total transport time of a multicomponent mixture of raw materials is 5 – 7 min and the number of pourings reaches 4 – 5 with several revolutions of the gallery.

The initial batch quality is maintained with complete automation of the transport process by using a container batch-feeding system. Such a system includes the following:

– a closed monorail path with a trackless trolley, consisting of two parallel branches for forward and return movement of containers and terminal sections for turning around in the compound and machine-tank shops;

– suspended transport containers with capacity 3 – 4 m^3, each equipped with a self-propelled monorail trolley, a current pick-off and an electric drive, feeding and suction connections, turning sector unloading gate, and a control panel;

– batch loading units equipped with suction pumps for dust and telescopic mechanisms for joining with the loading connections of the containers;

– stationary mechanisms for opening the sector gates of the containers, located on the sections for loading the hoppers of the loaders loading batch into the glassmaking furnace or intermediate hoppers of the system feeding measured amounts of batch and cullet;

– centralized monitoring and controlling system, consisting of a personal computer, sensors for identifying and locating every batch container as well as other means of automation.

In addition to the main monorail path, the container transport system also includes branch paths which can be reached by means of branching arrows and which permit removing individual containers from the general line for preventative maintenance and repairs and returning the containers into the line.

The total number of suspended batch containers in the transport line can reach 25 – 30 and depends on the productivity of the glassmaking furnace (or furnaces), the length of the gallery, and the velocity of the containers. Since the velocity of the containers is less than that of the trolleys, the transport time of each portion of batch in the containers increases. This results in undesirable compaction of the batch and complicates its off-loading. For this reason, an additional condition for replacing electric trolleys by a system of suspended containers is that the initial moisture content of the batch must be decreased to 2.5%, which is not always possible because of the technological requirements imposed on the glassmaking process and the intensified dusty generation from the batch when it is mixed with the cullet and loaded into the hoppers of the batch feeders.

In summary, when designing lines for transporting glass batch and choosing the corresponding technological equipment all factors affecting not only the general outfitting and architectural-construction solutions for compound shops and transport galleries but also the final quantity of batch loaded into the glassmaking furnace must be taken into account.

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